Prototype Testing of the Frankfurt Gabor Lens at HOSTI

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At the Institute for Applied Physics (IAP Frankfurt) the application of Gabor space charge lenses as a focusing device for low energy ion beams has already been studied for several decades with limitations to low currents. In mid-2012 the performance of a prototype lens has successfully been tested at the GSI High Current Test Injector (HOSTI).

GSI and IAP are currently investigating the possible application of such a device for the uranium operation at the new Terminal West for FAIR.

Prototype Gabor Lens

The prototype Gabor lens had been designed for focusing a $^{238}U^{4+}$ beam with an energy of 2.2 keV/u and a maximum beam radius of r_B=50 mm. In this context, emphasis was put on the homogeneity of the confined electron density distribution and connected to this the linearity of the electric space-charge field within the beam region to ensure transport free of aberrations [1].

Beam Transport Experiments at HOSTI

The beam transport measurements had been divided into two parts: low current measurements to study the quality of ion optics and high current measurements. In case of the low current measurements the focusing performance of the lens transporting a He^+ beam with currents up to 5 mA and beam energies of 12.6 keV/u was investigated. For the high current measurements an Ar^+ beam of currents up to 35 mA with beam energy of 3.1 keV/u was generated. In both cases the MUCIS ion source was operated in pulsed mode with a pulse length of 1.25 ms and a rep rate of 1 Hz [2]. Figure 1 shows a picture of the experimental setup at HOSTI.

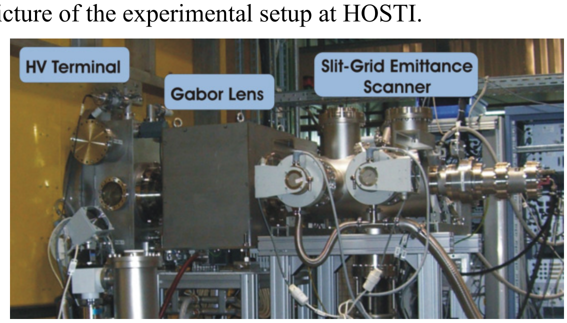

Figure 1: Picture of the experimental setup.

The low current measurements clearly show the influence of electron density distribution on the emittance figure (see Figure 2). In the illustrated beam transport simulations a compensation degree of 95 % was assumed.

The high current measurements demonstrate that this kind of Gabor lens is suitable for the transport of high current ion beams without reasonable emittance growth (see Figure 3).

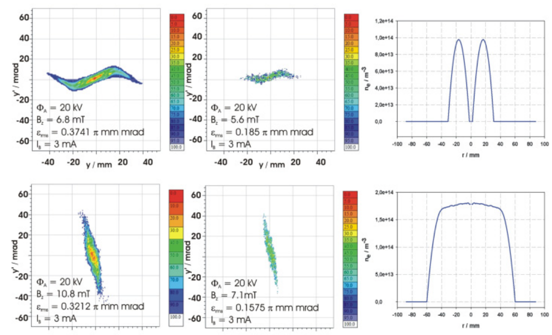

Figure 2: Comparison of measurement (left) and simulation of the transported He^+ beam (centre) as well as simulated electron density distribution (right).

A parallel beam is attained with lens parameters of Φ_A=9.8 kV and B_z=10.8 mT. One has to remark that the high current measurements were performed with an iris of 50 mm at the entrance of the lens to protect the insulator from the beam.

Improvements in the lens design concerning the magnetic field and the insulator of the electrode system are currently under discussion.

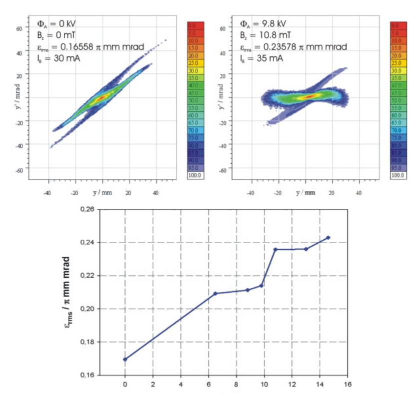

Figure 3: Phase space distribution of the drifted (left) and of the transported Ar^+ beam (right), emittance growth as a function of the confining magnetic field (bottom).

References

[1] K. Schulte, "Space Charge Lens for Focusing Heavy Ion beams", GSI Scientific Report, 2010.

[2] A. Adonin et al., "Measurements of Transverse Ion Beam Emittance Generated by High Current Ion Sources at the GSI Test Injector Facility HOSTI", Rev. Sci. Instrum. 81, 02B707(2010).